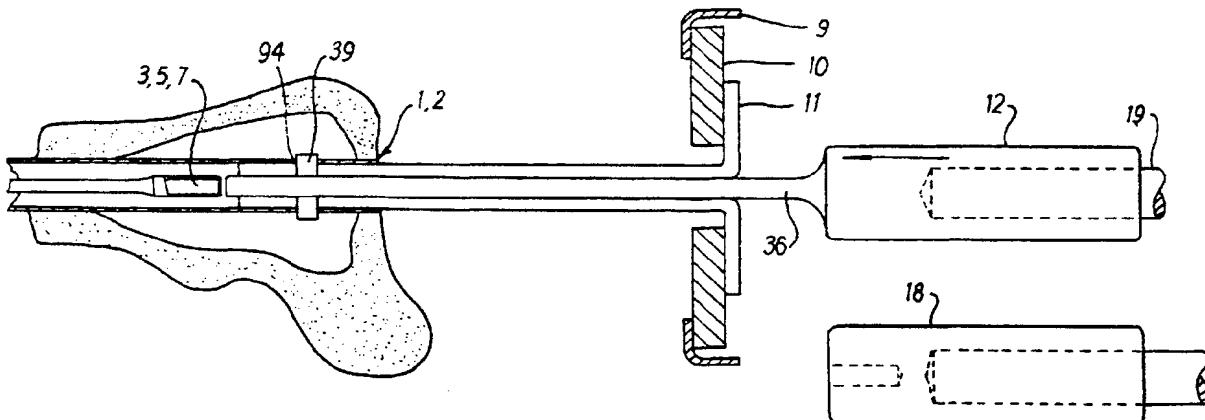




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## (54) Title: EXPANDING INTRAMEDULLARY NAIL



## (57) Abstract

An intramedullary nail (1) is expandable along its entire length enabling it to be inserted inside a broken bone in its non-expanded form and then expanded so as to secure the bone. Such insertion can be performed without drilling into the bone and the securing of a bone using such a nail alleviates the need for subsidiary pins or nails, thus reducing operation time. Such a nail may consist of a hollow tube with broken cross section which may be expanded by forcing an insert into the break in cross section thus prising it apart.

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1       Expanding Intramedullary Nail

2

3       The present invention relates to an expanding  
4       intramedullary nail for uniting bone fragments and to  
5       apparatus for operating the nail.

6

7       Conventionally, nails and fixing pins for bone  
8       fractures require the bone to be drilled out before the  
9       nail or pin can be inserted. This results in loss of  
10      tissues which are important for bone growth and healing  
11      and can result in fat embolism while drilling. Known  
12      devices comprise hollow sleeves accommodating  
13      mechanisms, typically for extending flukes to anchor  
14      the pin on the inside of the bone.

15

16      One of the disadvantages encountered with known devices  
17      is that once the nail or pin is *in situ* it cannot  
18      easily be removed; this can cause serious problems if a  
19      nail or pin becomes stuck before reaching its final  
20      position. Such nails may also need holding in place by  
21      other nails, necessitating long operations and  
22      sometimes additional operations specifically to insert  
23      or remove the subsidiary nails.

24

25      According to the present invention there is provided

1       apparatus for pinning one or more bone elements  
2       comprising an intramedullary nail which is selectively  
3       cross-sectionally expandable along substantially its  
4       entire length, an expander for said nail and operating  
5       means for operating said nail in conjunction with said  
6       expander.

7

8       Preferably, the nail is elongate and hollow.

9

10      Preferably, the nail is expandable *in situ* within a  
11      bone.

12

13      Preferably, the nail has a broken cross section along  
14      substantially its entire length and is expandable by  
15      enlarging the break in the cross section.

16

17      The nail may be configured so as to be enlargeable by  
18      an expander in the form of an elongate insert, inserted  
19      into the hollow portion of the nail, where said insert  
20      comprises a plurality of elongate members having  
21      adjacent cooperating surfaces and configured such that  
22      relative axial movement of the elongate members results  
23      in their non cooperating surfaces being forced away  
24      from each other producing an increase in the total  
25      effective cross section of the insert.

26

27      Alternatively, the break in the cross section may be  
28      configured so as to accommodate the insertion of an  
29      expander or a selected one of a plurality of expanders,  
30      each expander being in the form of an elongate member,  
31      insertion of said expander prising open the break in  
32      the cross section by an amount determined by the size  
33      and shape of the expander and each expander having a  
34      portion configured so as to be engageable by an  
35      expander insertion and/or extraction means.

1 Preferably, the elongate expander has a shaped portion  
2 configured to engage a portion of the inside surface of  
3 the intramedullary nail configured to have a  
4 complementary shape.

5

6 Preferably, there is provided apparatus for expansion  
7 and/or reversing said expansion, of the nail comprising  
8 engaging means which engage the nail and means for  
9 applying or releasing a force to or from said nail.

10

11 Preferably, said apparatus is for insertion and/or  
12 extraction of an expander comprising a push and/or pull  
13 member which engages the expander, a forcing means  
14 which provides force to the push and/or pull member and  
15 nail engaging means which helps reduce movement of the  
16 nail relative to said apparatus.

17

18 The forcing means may comprise a screw jack mechanism,  
19 ratchet mechanism or other substantially non-percussive  
20 mechanism.

21

22 Embodiments of the present invention will now be  
23 described by way of example with reference to the  
24 accompanying drawings in which:

25

26 Fig 1a is a cross-section of an embodiment of an  
27 expanding intramedullary nail and a portion of an  
28 apparatus for insertion of an expander insert in  
29 accordance with the present invention;

30

31 Fig 1b is a cross-section of an embodiment of an  
32 expanding intramedullary nail and a portion of an  
33 apparatus for withdrawal of the expander insert in  
34 accordance with the present invention;

35

1       Fig 2a and Fig 2b are cross-sections corresponding  
2       to Figs 1a and 1b of an alternative embodiment;

3

4       Figs 3a-3f are cross-sections of the expanding  
5       intramedullary nail of Fig 1 and expander insert  
6       in accordance with the present invention;

7

8       Figs 4a-4e are cross-sections of an embodiment of  
9       an intramedullary nail and expander inserts,  
10      alternative to those shown in fig 3a-3f. Fig 4f  
11      is a further embodiment of an intramedullary nail;

12

13      Fig 5a and Fig 5b are side views of an apparatus  
14      for operation of an expanding intramedullary nail  
15      in accordance with the present invention; the  
16      apparatus of Fig 5a is for insertion and the  
17      apparatus of Fig 5b for withdrawal of an expander  
18      insert;

19

20      Figs 6a, 6b, 7a, 7b, 8a and 8b are side and  
21      frontal views showing alternative embodiments of  
22      apparatus for operation of an expanding  
23      intramedullary nail, in accordance with the  
24      present invention;

25

26      Figs 9a, b and c are a broken side view, end view  
27      and top view respectively of an intramedullary  
28      nail in accordance with the present invention;

29

30      Figs 10a and b are side and end views of an  
31      alternative embodiment of an intramedullary nail  
32      in accordance with the present invention;

33

34      Figs 11a, b and c, are side, end and top views  
35      respectively of an expander of the apparatus of

1           Fig 1a, 1b, 2a or 2b;

2  
3           Figs 12a and 12b show side and end views,  
4           respectively of an expander of the type  
5           illustrated in Figs 4a-4e;

6  
7           Figs 13a and 13b show an alternative form of  
8           expander insert;

9  
10          Fig 14 shows a preferred embodiment of apparatus  
11          similar to the apparatus of Figs 6a,b;

12  
13          Figs 15a, b show a push member for use with the  
14          apparatus of Fig 14;

15  
16          Figs 16a,b show a pull member for use with the  
17          apparatus of Fig 14; and

18  
19          Fig 17 shows a cross section of an intramedullary  
20          nail which incorporates a locking mechanism and  
21          could be used with the expander of Figs 13a,b.

22  
23          Referring to the drawings a first embodiment or  
24          embodiments of the present invention shall be presented  
25          with reference to Figs 1a, b, 2a, b, 3a-f, 5a,b, 9a-c,  
26          and 11a-c. Thereafter further alternative embodiments  
27          shall be described with reference to Figs 4a-f, 6a,b,  
28          7a,b, 10a,b 7a,b, 12a,b, 13a,b, 14 and 15a,b.

29  
30          The first embodiment of the present invention comprises  
31          an expandable nail 1 in the form of an elongate tube  
32          having a longitudinal slit 30 in the tube wall 31. The  
33          expandable nail 1 has a number of expander inserts 3,  
34          5, 7 to give a range of degrees of expansion. Each  
35          expander insert 3, 5, 7 is formed of an elongate member

1       40 with a screw-threaded attachment end member 41. The  
2       elongate member 40 is of generally rectangular cross-  
3       section 42 with each expander insert 3, 5, 7 having a  
4       different width of a first portion 37 of the  
5       rectangular cross-section 42, which portion 37  
6       corresponds when *in situ*, with the longitudinal slit 30  
7       of the expandable nail 1 (Fig 8c). Six expander  
8       inserts 3, 5, 7 are illustrated in Fig 3a to 3f with  
9       variable widths of first portion 37 of the rectangular  
10      cross-section 42, the widths of the first portion 37  
11      vary from 1 to 3.5 mm.

12

13      An expander insertion device 32 has a push rod 12, two  
14      draw bars 11, a thrust plate 9, 13 or 14 and a  
15      modification to the thrust plate 10. The push rod 12  
16      has a thin elongate member 36 a first end of which is  
17      attachable to the end member 41 of the expander insert  
18      3, 5 or 7, while a second end of the push rod 12 has an  
19      attachment sleeve 16 for attachment of a push rod  
20      extension 22.

21

22      The insertion device 32 has a sprung ratchet tool 34,  
23      attached to an end plate 21 orthogonally situated  
24      around the push rod extension 22. The ratchet tool 34  
25      is manually operable by means of a handle 38. The end  
26      plate 21 is connected to the thrust plate 9 by two tie  
27      rods 20, 23 which are disposed on either side of the  
28      push rod 12 and push rod extension 22. The thrust  
29      plate 9 and end plate 21 have centrally disposed  
30      apertures through which the push rod 12 and push rod  
31      extension 22 are situated. The ratchet tool 34 is  
32      placed against the end plate 21 and pushes the push rod  
33      12 linearly along the longitudinal axis of the push rod  
34      12 towards the expandable nail 1.

35

1       The draw bars 11 comprise elongate members each having  
2       a first end with a transverse pin 39 for location of  
3       the draw bar 11 in a fixed position to the expandable  
4       nail 1. The pin 39 is situated a short distance from  
5       the first end of the draw bar 11 and attached to the  
6       proximal end of the expandable nail 1 by engaging a  
7       hole 94 in said nail 1. Figs 3a to 3f show a cross-  
8       section of the pins 39 of the draw bars 11 and the  
9       expandable nail 1. The draw bars 11 and pins 39 are  
10      locked into place with respect to the nail 1 by  
11      insertion of the push rod 12, 36 between the two draw  
12      bars 11.

13

14      A short distance from the second ends of the two draw  
15      bars 11, the elongate members bend through 90°. These  
16      orthogonal portions of the elongate members project  
17      from the longitudinal axis of the push rod 12. The  
18      thrust plate 9 and modification 10 are disposed around  
19      the draw bars 11 and the push rod 12 such that the  
20      orthogonal portions of the draw bars 11 are adjacent to  
21      the thrust plate modification 10 on the opposite side  
22      of the thrust plate 9 to the expanding intramedullary  
23      nail.

24

25      An expander extraction device has a pull rod 15 which  
26      is attachable to the end of the expander insert 41  
27      within the expandable tube 1. The pull rod 15 has a  
28      diameter such that it fits closely within the  
29      expandable nail 1. Two pull rods 15, 24 may be  
30      connected by means of a screw threaded sleeve 16. A  
31      withdrawal thrust plate 13, 14 is positioned against  
32      the proximal end of the expandable nail 1 and the  
33      thrust plate 13, 14 has a central opening through which  
34      the pull rod 15, 24 is positioned. The sleeve 16 is  
35      positioned on the opposite side of the thrust plate 13,

1       14 to the expandable nail 1.

2

3       The expander extraction device 33 has a sprung ratchet  
4       tool 35 attached to an end plate 25 situated  
5       orthogonally around the pull rod 15, 24. The end plate  
6       25 and thrust plate 13, 14 are connected by two tie  
7       rods 20, 23 which are disposed on either side of the  
8       pull rod 15, 24. The end plate 25 and thrust plate 13,  
9       14 have centrally disposed apertures through which the  
10      pull rod 15, 24 is situated. The ratchet tool 35 is  
11      adjacent to the end plate 25 and pulls the pull rod 15,  
12      24 linearly along the longitudinal axis of the pull rod  
13      15, 24 away from the expandable nail 1.

14

15      In use, the expanding intramedullary nail in its  
16      unexpanded form is positioned in its desired position  
17      inside a bone along the axis of the bone thereby  
18      joining any fracture in the bone.

19

20      The expandable nail 1 is between 8 and 12 mm in  
21      diameter depending on the dimensions of the bone and  
22      approximately 320 mm long with a minimum wall thickness  
23      of 0.5 to 1.0 mm. Intramedullary nails in accordance  
24      with the present invention may be of any of a variety  
25      of sizes according to the dimensions of the bone.

26

27      The expander insert 3, 5, 7 is inserted into the  
28      expandable nail 1 such that the expandable nail 1  
29      expands along its whole length. The expander insert 3,  
30      5, 7 is inserted with the first portion 37 of the  
31      expander insert 3,5,7 corresponding to the longitudinal  
32      slit 30 of the expandable nail 1, situated in the slit  
33      30. The expandable nail 1 is forced to expand as the  
34      width of the first portion 37 of the expander insert is  
35      greater than the natural width of the slit 30 in its

1 unexpanded form. The degree of expansion of the  
2 expandable nail 1 can be controlled by choice of the  
3 appropriately sized expander insert as shown in Fig 3a  
4 to 3f.

5

6 The expander inserts 3, 5, 7 are pushed into the  
7 expandable nail 1 by use of an expander insertion  
8 device 32. The device is arranged as described above  
9 such that the action of the sprung ratchet tool 34 can  
10 be manually operated by means of a sprung handle 38.  
11 Each operation of the handle 38 pushes the push rod 12,  
12 22 a discrete distance along the direction of the push  
13 rod's 12, 22 longitudinal axis such that it pushes the  
14 expander insert into the expandable nail 1.

15

16 The ratchet tool 34 is fixed to the end plate 21 by a  
17 weld or braze to a frame projecting from the end plate  
18 21. The thrust plate 9 is held a fixed instance from  
19 the end plate 21 by the connecting tie bars 20, 23  
20 between the plates 9, 21. The draw bars 11 have  
21 orthogonal portions situated on the opposite side of  
22 the thrust plate 9 to the expandable nail such that the  
23 pushing action of the ratchet tool 34 is relayed to the  
24 push rod 12 and the expander 3, 5, 7 and does not move  
25 the expandable nail 1.

26

27 When the selected expander is fully inserted into the  
28 expandable nail 1, the insertion device 32 can be  
29 removed. The expander can remain in position until  
30 such time as the expansion of the nail is to be  
31 reversed, that is, just prior to its repositioning or  
32 removal from the bone. The expander extraction device  
33 can be positioned with a pull rod 15, 24 attached to  
34 the expander insert 3, 5, 7 within the expandable nail  
35 1. The thrust plate 13, 14 is positioned against the

1 proximal end of the expandable nail 1 and held in fixed  
2 connection with the end plate 25 by tie rods 20, 23.  
3 The ratchet tool 35 for withdrawal is fixed to the end  
4 plate 25 as described for the ratchet tool 34 for  
5 insertion. Each operation of the sprung ratchet tool  
6 35 is manually operated by means of a sprung handle 38,  
7 pulling the pull rod 15, 24 a discrete distance along  
8 the longitudinal axis of the pull rod 15, 24 out of the  
9 expandable nail 1.

10

11 On withdrawal of the expander insert 3, 5, 7 the  
12 extraction device 33 can be removed.

13

14 Once the expander has been removed, the nail, being  
15 made from a resilient material, is allowed to revert to  
16 approximately its unexpanded size and shape and can be  
17 removed and used again or repositioned if necessary.  
18 Thus problems encountered when a nail is wrongly  
19 positioned or obstructed before reaching its final  
20 position are overcome.

21

22 One form of expandable nail can accommodate a range of  
23 sizes of bone and fracture although various sizes of  
24 nail would be used according to the circumstances. No  
25 drilling of the bone is necessary as the insertion  
26 device 32 slowly pushes an expander insert 3, 5, 7 into  
27 the expandable nail 1. The nail itself can be  
28 positioned manually prior to expansion without drilling  
29 because it need only be forced through relatively soft  
30 medullary tissue.

31

32 The expandable nail 1 and the expander inserts 3, 5, 7  
33 are made of a titanium alloy and all the other  
34 components of the apparatus are made of stainless steel  
35 except the end plates 25, 21 which are made of mild

1       steel.

2

3       Further embodiments of the present invention will now  
4       be described.

5

6       Fig 4a-e shows an alternative cross-sectional  
7       configuration for an intramedullary nail and a series  
8       of expander inserts to that shown in Fig 3a-f.

9

10      The cross section of the nail of this embodiment is not  
11      circular but is configured so as to slidingly engage a  
12      shaped portion of the expander insert, as the expander  
13      is inserted into or withdrawn from the nail.

14

15      This alternative configuration gives greater stability  
16      of position of the expander insert as it moves relative  
17      to the nail, and also helps prevent rotation of the  
18      nail with respect to the bone.

19

20      Fig 4f shows a slightly differently shaped, but  
21      functionally similar intramedullary nail to those shown  
22      in Figs 4a-e.

23

24      Figs 6a,b, 7a, b and 8a, b show side views (6a, 7a, 8a)  
25      and front views (6b, 7b, 8b) of alternative expander  
26      insertion/extraction devices 600, 700, 800 to those  
27      shown in Fig 5a,b.

28

29      Each of the devices has a similar structure to the  
30      devices of Figs 5a, b except that a screw jack  
31      mechanism is used in place of the ratchet mechanism and  
32      that power can be provided either manually by turning a  
33      handle 601 or by an electric motor which is supplied by  
34      a lead 704, 804 or possibly battery operated (not  
35      shown). Other methods of providing a force, such as

1       hydraulics could also be used.

2

3       Fig 6b shows an expander insertion/extraction device  
4       600 having two handles 601, 602 and a threaded rod 603  
5       which, when rotated, acts as a screw jack mechanism  
6       providing a controllable force for the insertion of an  
7       expander into, or extraction of an expander from, an  
8       intramedullary nail. The device includes a rear end  
9       plate 621 and a front end plate 609 which are connected  
10      by tie rods 620, 623. The rear of the threaded rod 603  
11      passes through a threaded aperture in the rear end  
12      plate 621 and attaches rigidly to a handle 601 such  
13      that rotation of the handle 601 also rotates the  
14      threaded rod 603 and controls its movement through the  
15      aperture in the end plate 621 thus controlling the  
16      length of the threaded rod which extends from the rear  
17      end plate 621 towards the front end plate 609.

18

19       The threaded rod 603, at its end nearest the front end  
20      plate 609, engages a thrust plate 608 which moves along  
21      the tie rods 620, 623, that is in a substantially  
22      straight line between the front end plate 609 and the  
23      rear end plate 621. The thrust plate 608 engages a  
24      push/pull member 624 which passes through an aperture  
25      in the front end plate 609 and attaches to the expander  
26      which is to be forced.

27

28       Thus in use, rotation of the handle 601, which can be  
29      performed manually, results in a force, in an axial  
30      direction according to the direction of the rotation,  
31      on the expander.

32

33       The expander insertion/extraction devices shown in figs  
34      7a and 8a, 700, 800 respectively, work in a similar  
35      manner to the device 600 and will thus not be described

1       in detail. Corresponding parts of each of the three  
2       devices are denoted by three figure numerals in which  
3       the first digit denotes the device and the latter two  
4       digits are common.

5

6       Two of the devices 700,800 are shown as being operated  
7       by an electric motor supplied by a flex 704,804. Thus  
8       the handles 701,801 do not rotate and the screw  
9       threaded rod does not attach to the handle 701,801 but  
10      is driven by the electric motor via transmission  
11      components in the housing 770,870.

12

13      The two electrically driven devices 700,800 are  
14      operated by use of buttons 750,851,852 located on a  
15      handle of the device. One of the devices 800 is shown  
16      as having two buttons 851,852 one corresponding to each  
17      direction of rotation of the threaded rod.

18

19      The front views of the devices show a vertical member  
20      690, 790, 890. This member is for use in attaching the  
21      push/pull member to the expander. As an alternative to  
22      the screw portion 3 of the expander 40, an expander  
23      could be configured with an aperture adjacent to one  
24      end of said member as shown in Figure 12. In use the  
25      member 690,790,890 passes through the aperture thus  
26      securely engaging the expander.

27

28      In Figs. 6a, 7a and 8a the nail extends a distance  
29      outside the bone while it is being expanded. Having a  
30      portion of the nail extending from the bone has  
31      benefits over inserting it so that it is entirely  
32      contained within the bone, in that it prevents or  
33      reduces the growth of callus over the nail and also  
34      facilitates subsequent removal of the nail from the  
35      bone.

1       Fig 10 a,b shows an alternative embodiment of an  
2 expandable intramedullary nail to that shown in Fig 9  
3 a,b,c. The cross sectional shape, shown in Fig 10b, is  
4 not round but is shaped to help prevent rotation of the  
5 nail relative to the bone and also to help guide a  
6 suitably shaped expander into or out of the nail. It  
7 can also be seen from Fig 10a that the break in cross  
8 section 1030 is flared, widening towards the end where  
9 an expander would be inserted. This facilitates the  
10 initial insertion of the expander. The end which would  
11 be foremost when the nail is inserted into a bone is  
12 shaped without sharp corners in order to prevent  
13 catching on the inside of the bone and facilitates  
14 insertion of the nail into the medullary cavity.

15

16      Fig 12a shows a side view and Fig 12b shows an end view  
17 of the type of expander illustrated in Fig. 4. An  
18 aperture 1201 is provided as a means of attachment to  
19 an insertion or extraction device as described above.

20

21      Figs 13a, b show a further embodiment of an expander  
22 for an expanding intramedullary nail comprising two  
23 longitudinal sections 1305, 1306 which have teeth with  
24 corresponding angled surfaces. The angled surfaces of  
25 the teeth are arranged such that a force applied to a  
26 first end 1309 of one of the longitudinal sections  
27 1302, causing it to move in an axial direction relative  
28 to the other longitudinal section 1301, results in  
29 angled surfaces of the teeth 1303,1304 moving against  
30 each other and gradually disconnecting as shown in Fig  
31 13b, causing corresponding motion of the sides of the  
32 expander 1305,1306, away from each other.

33

34      In use the expander insert is inserted in its  
35 unexpanded form into the intramedullary nail (not

1 shown). Apparatus (not shown) would be provided to  
2 force the longitudinal sections 1301, 1302 to move  
3 axially relative to each other. Such apparatus might  
4 comprise a device such as shown in any one of Figs 5-8  
5 with the addition of an attachment means to prevent  
6 movement of the longitudinal section of the expander  
7 insert which is to remain stationary. Thus the  
8 longitudinal sections would be forced to move relative  
9 to each other thereby causing the expansion of the  
10 expander insert as detailed above.

11

12 The expander insert, on expansion, forces the  
13 intramedullary nail to expand with the break in cross-  
14 section widening to accommodate the expander insert.

15

16 Use of an expander of this type requires a locking  
17 mechanism either on the expander itself, or on the  
18 nail. Such a locking mechanism would be necessary to  
19 maintain the nail in its expanded state. A locking  
20 mechanism on the expander would require the expander to  
21 be left in the nail for as long as the expanded state  
22 is required. If the locking mechanism were on the nail  
23 the expander could be removed leaving the lock expanded  
24 nail *in situ* in the patient's bone.

25

26 Fig 14 shows a preferred embodiment of an expander  
27 insertion/extraction device 1400 similar to that shown  
28 in Fig 6.

29

30 In this embodiment there is a threaded rod 1403 which  
31 is hollow and contains a solid rod 1404 which extends  
32 through a thrust plate 1408. The solid rod 1404 is  
33 attached to a push/pull member 1461 by a locking device  
34 1478 which provides two pins 1479, 1480 one of which  
35 passes through the solid rod 1404 and of one which

1 passes through the push/pull member 1461. The solid  
2 rod 1404 is secured to the thrust plate 1408 by a pin.  
3 This arrangement gives secure connection of the  
4 threaded rod 1403 to the thrust plate 1408 and  
5 push/pull member 1461/1462 during both insertion and  
6 extraction procedures.

7

8 The expander insertion/extraction device also includes  
9 two pins 1439, which, in use, engage apertures in an  
10 intramedullary nail 1401 in order to secure the device  
11 to the nail. The pins 1439 are attached to members  
12 1440 which engage the outside of the nail 1401, thus  
13 differing from the arrangement shown in Figs 1a, 2a and  
14 greatly facilitating the insertion of the pins 1439  
15 into the apertures. The pins 1439 are secured in the  
16 apertures by a circlip 1474 which forces the members  
17 1440 against the outside of the nail 1.

18

19 Push and pull members 1461,1462 for use with the device  
20 of Fig 14 are shown in Fig 15a,b and 16a,b  
21 respectively.

22

23 The push member 1461 consists of a rod which has one  
24 end portion configured for attachment to the solid rod  
25 1404 via the locking device 1478 and the other end  
26 portion configured for engaging, and applying a pushing  
27 force to, an expander.

28

29 A pull member 1462 consists of a rod similar to the  
30 push member 1461 except that the end portion which  
31 engages an expander is configured for the application  
32 of a pulling force.

33

34 The portion of the push member 1461 or pull member 1462  
35 configured to be attached to the solid rod 1404 of the

1 insertion/extraction device 1400 comprises a flattened  
2 part with an aperture. The aperture, in use, engages  
3 the pin 1479 which is provided by the locking device  
4 1478.

5

6 The portion of the push member 1461 configured to  
7 engage the expander comprises a slot into which a  
8 portion of the expander fits.

9

10 The portion of the pull member 1462 configured to  
11 engage the expander comprises a hook shaped member  
12 which, in use, passes through the aperture 1201 of an  
13 expander such as that shown in Fig. 12a.

14

15 Fig. 17 shows a cross section of an intramedullary nail  
16 according to the present invention which incorporates a  
17 locking device such that it could be suitable for use  
18 with the expander insert shown in Figs 13a,b.

19

20 The nail comprises a cylindrical tube 1700 with a break  
21 in cross section 1704 and a pair of members 1705,1706  
22 extending from either side of the break in cross  
23 section into the interior of the cylindrical tube 1700.  
24 The members 1705,1706 are curved or bent, and  
25 configured such that expansion of the tube by  
26 increasing the size of the break in cross section  
27 causes at least some portions of the members to move  
28 longitudinally against each other. The portions of the  
29 members which move against each other are each equipped  
30 with teeth with inclined surfaces configured such that  
31 motion of the members 1705,1706 against each other in  
32 the direction that corresponds to expansion of the tube  
33 1100 is possible, but motion in the opposite direction  
34 is prevented for as long as the teeth 1703 on the two  
35 members 1705,1706 engage each other.

1       The two members 1705,1706 include portions 1707,1708  
2       spaced apart from each other. These spaced portions  
3       1707,1708 are parallel to and proximate to the toothed  
4       portions.

5

6       The two members 1705,1706 are configured such that the  
7       toothed portions are aligned substantially orthogonal  
8       to a radius of the cylindrical tube 1700 that crosses  
9       the break in cross section 1704. The members 1705,1706  
10      are also configured so as to allow an expander 1701 of  
11      the type shown in Fig 13 to be inserted into the  
12      cylindrical tube 1700 and occupy a diameter of the tube  
13      substantially parallel to the toothed portions of the  
14      members 1705,1706.

15

16      In use the tube 1700 is inserted in its unexpanded form  
17      into the medullary cavity of the bone to be secured.  
18      An expander 1701 of the type shown in Figs 13a,b and  
19      described above is then inserted into the hollow  
20      portion of the tube 1700.

21

22      An operating means (not shown) is then used to operate  
23      the expander 1701 and thus expand the tube by the  
24      desired amount. As the tube 1700 expands, the teeth  
25      1703 on the members 1705,1706 slide over each other.

26

27      When the desired expansion of the tube has been  
28      obtained the expander may be returned to its original  
29      configuration (as shown in Fig 13a) and the nail  
30      remains expanded, unable to return to its expanded state  
31      because of the engaging teeth 1703 on the members  
32      1705,1706. The operating means and expander 1701 can  
33      thus be removed from the proximity of the nail leaving  
34      the nail in its expanded form.

35

1       When the expansion of the nail is to be reversed an  
2       elongate member can be inserted into a space, 1702,  
3       formed by the spaced apart portions 1707,1708 of the  
4       members 1705,1706. Insertion of the elongate member,  
5       which is dimensioned to be slightly larger than the  
6       natural distance between the spaced apart portions  
7       1707,1708 of the members 1705,1706, forces the spaced  
8       apart portions 1707,1708 away from each other thus  
9       disengaging the teeth and allowing the tube 1700 to  
10      revert to its unexpanded form.

11

12      Improvements and modifications may be incorporated  
13      without departing from the scope of the invention.

1       CLAIMS

2

3       1     Apparatus for pinning one or more bone elements  
4           comprising an intramedullary nail being  
5           selectively cross-sectionally expandable along  
6           substantially the entire length of the nail, an  
7           expander for said nail, and operating means for  
8           operating said nail in conjunction with said  
9           expander.

10

11      2     An intramedullary nail being selectively cross  
12           sectionally expandable along substantially the  
13           entire length of the nail.

14

15      3     A nail as claimed in Claim 2 wherein the nail is  
16           hollow and elongate.

17

18      4     A nail as claimed in either of Claims 2 or 3  
19           wherein the nail is expandable *in situ* within a  
20           bone.

21

22      5     A nail as claimed in any one of Claims 2 to 4,  
23           wherein the nail has a broken cross section  
24           throughout substantially its entire length and is  
25           expandable by enlarging the break in the cross  
26           section.

27

28      6     A nail as claimed in any one of Claims 3 to 5,  
29           wherein the nail is configured so as to be  
30           enlargeable by an expander in the form of an  
31           elongate insert, inserted into the hollow portion  
32           of the nail.

33

34      7     A nail as claimed in Claim 5 wherein the break in  
35           cross section is configured so as to accommodate

1       the insertion of an expander or successive  
2       insertion of a plurality of expanders, each  
3       expander being in the form of an elongate member.  
4

5       8     An expander for use in the apparatus of Claim 1,  
6       comprising a first portion for engagement of an  
7       intramedullary nail and a second portion  
8       configured to be engaged by an operating means for  
9       said nail and expander.

10

11      9     An expander as claimed in Claim 8 wherein the  
12       expander is in the form of an elongate insert for  
13       insertion into a hollow portion of an expandable  
14       intramedullary nail.

15

16      10    An expander as claimed in Claim 9 wherein the  
17       elongate insert comprises a plurality of elongate  
18       members having cooperating surfaces and configured  
19       such that relative axial movement of the members  
20       results in their non-cooperating surfaces being  
21       forced away from each other effecting an increase  
22       in the total cross section of the insert.

23

24      11    An expander as claimed in Claim 8 or 9 wherein the  
25       first portion is insertable into the break in  
26       cross section of the nail of Claim 5, and is  
27       adapted to prise open the break by an amount  
28       determined by the size and shape of the expander,  
29       and the second portion is configured so to be  
30       engageable by an expander insertion/extraction  
31       means.

32

33      12    An expander as claimed in Claim 11 having a shaped  
34       portion configured to engage a portion of the  
35       inside surface of an intramedullary nail

1           configured to have a complementary shape.

2

3     13   Operating means for use with an intramedullary  
4       nail, said nail being expandable along  
5       substantially its entire length, comprising  
6       engaging means which engages the nail and means  
7       for applying or releasing a force to or from said  
8       nail.

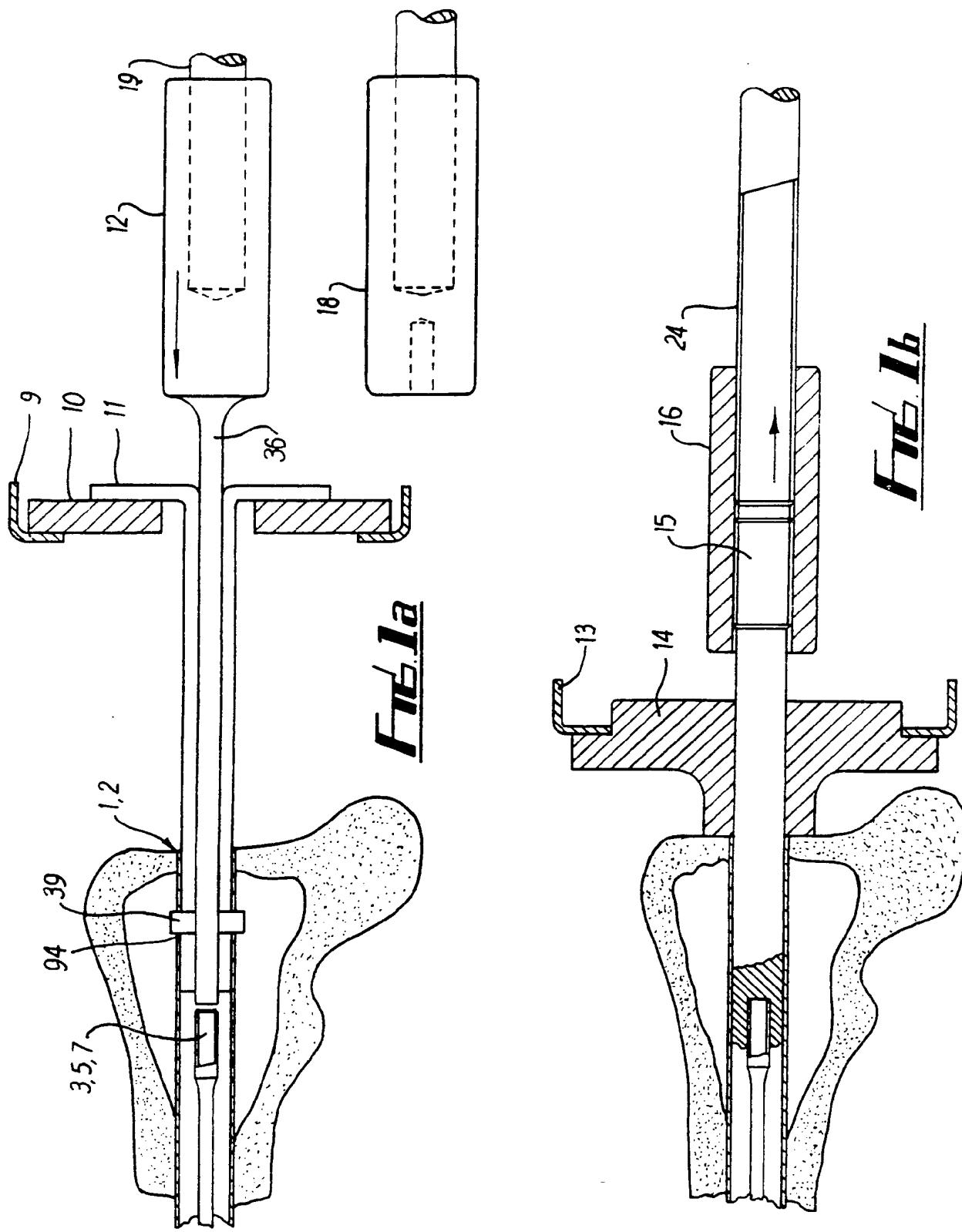
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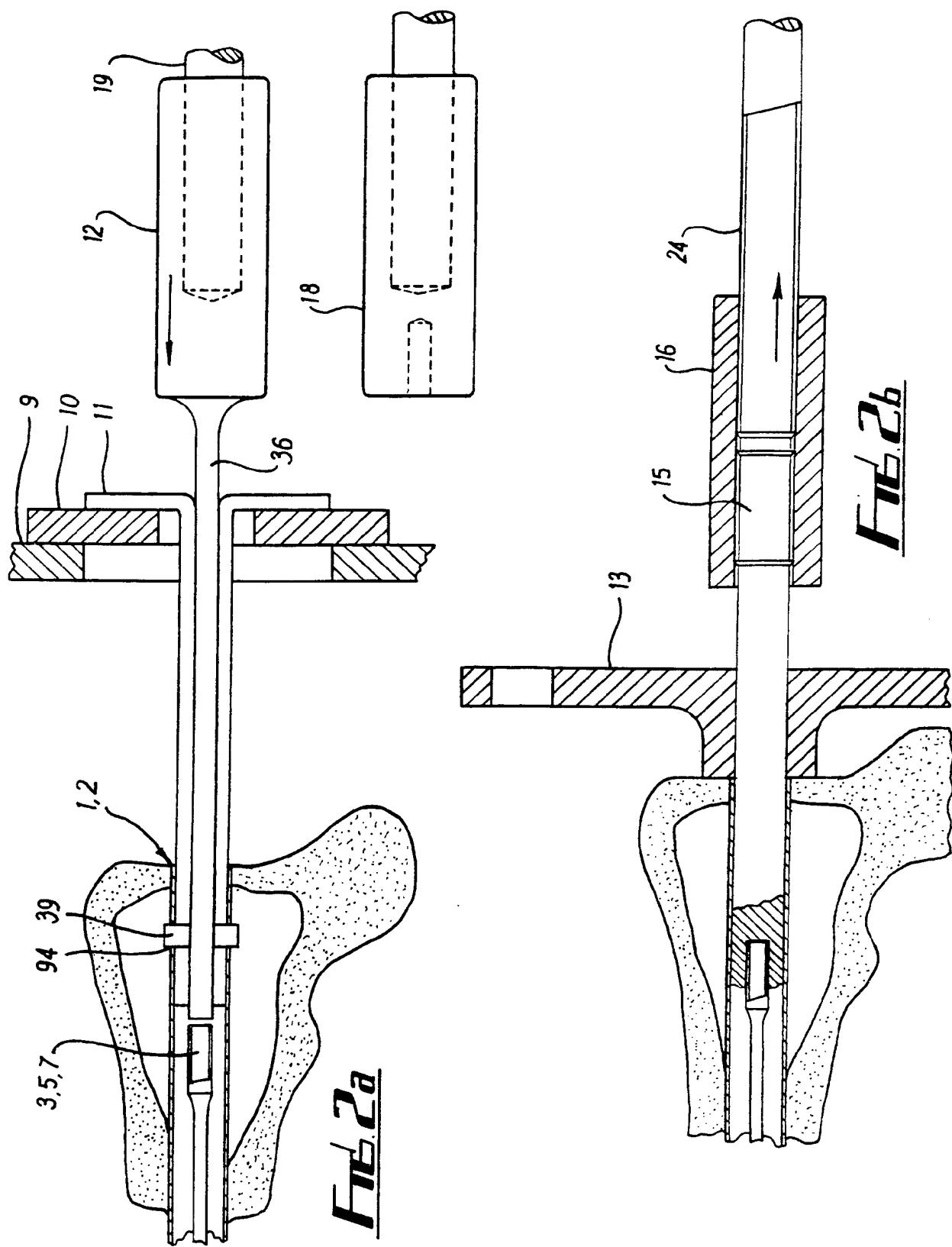
10    14   Operating means as claimed in Claim 13, being  
11      adapted for the insertion and/or extraction of an  
12      expander, comprising a push and/or pull member  
13      adapted to engage the expander, forcing means  
14      which provides force to the push and/or pull  
15      member and nail engaging means, which in use,  
16      braces the nail against the operating means.

17

18    15   Operating means as claimed in Claim 13 or 14  
19      wherein the forcing means comprises a screw jack  
20      mechanism, ratchet mechanism or other  
21      substantially non-percussive mechanism.

22





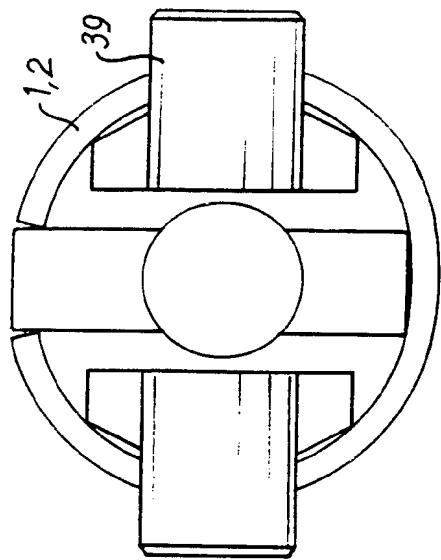


FIG. 3c

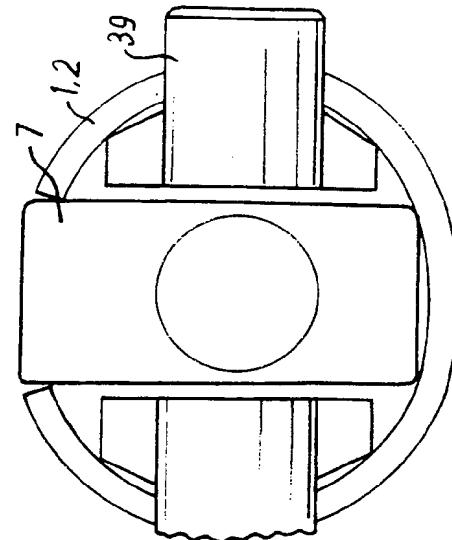


FIG. 3f

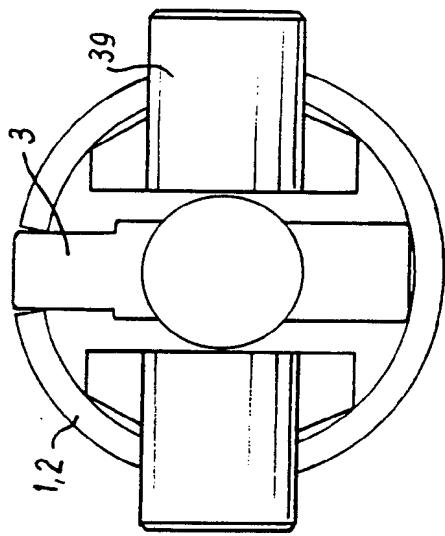


FIG. 3h

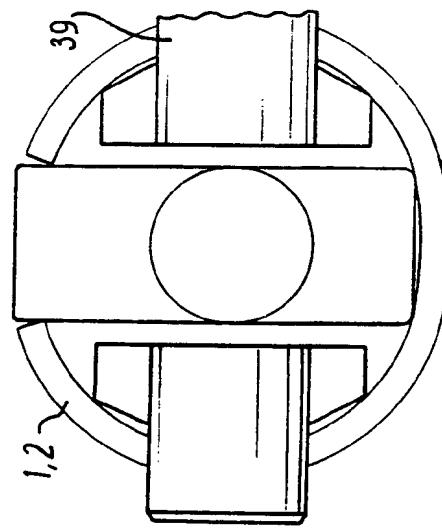


FIG. 3e

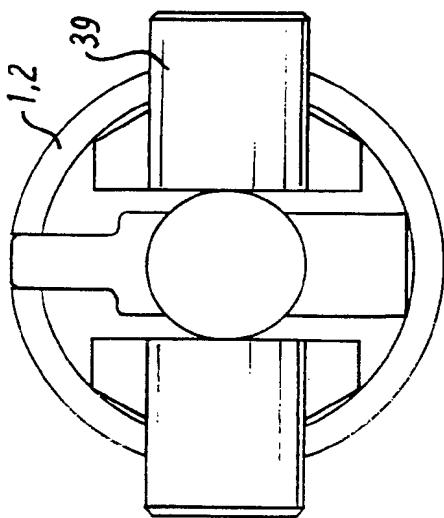


FIG. 3a

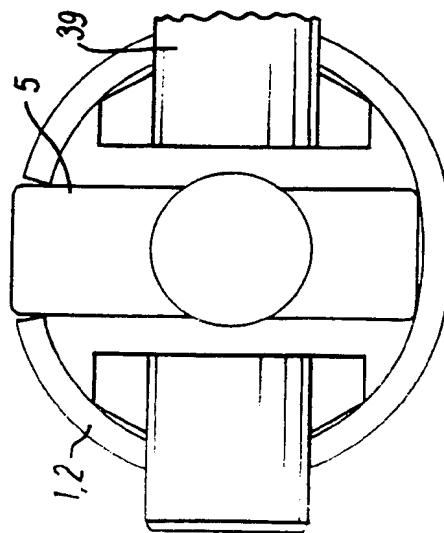


FIG. 3d

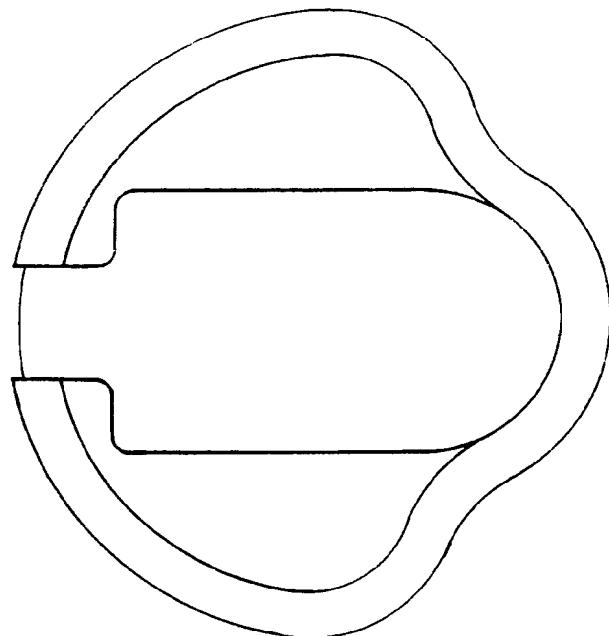


FIG 4b

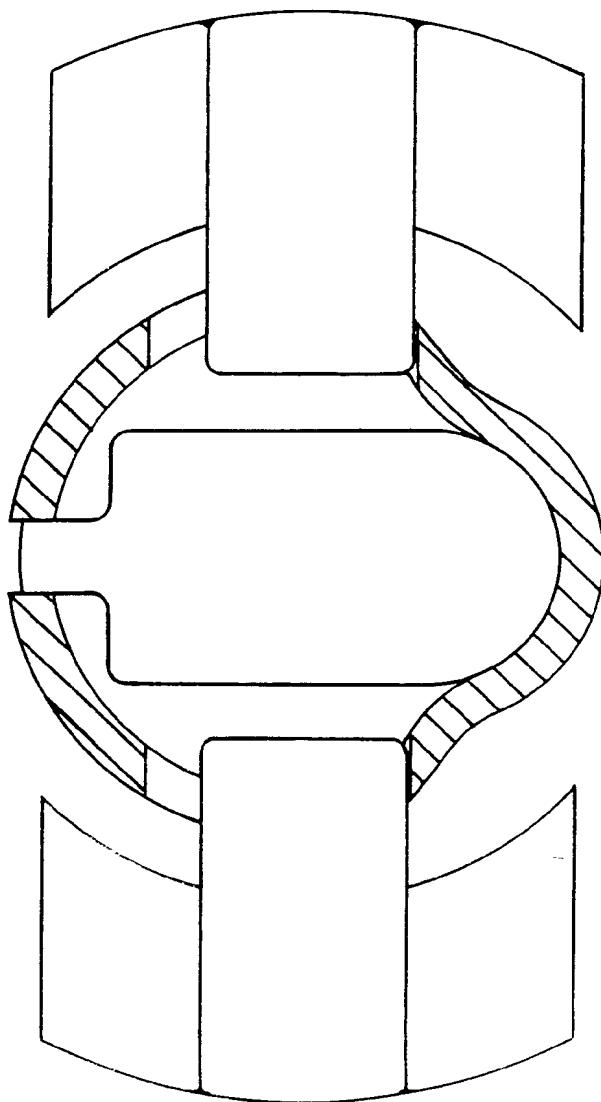


FIG 4a

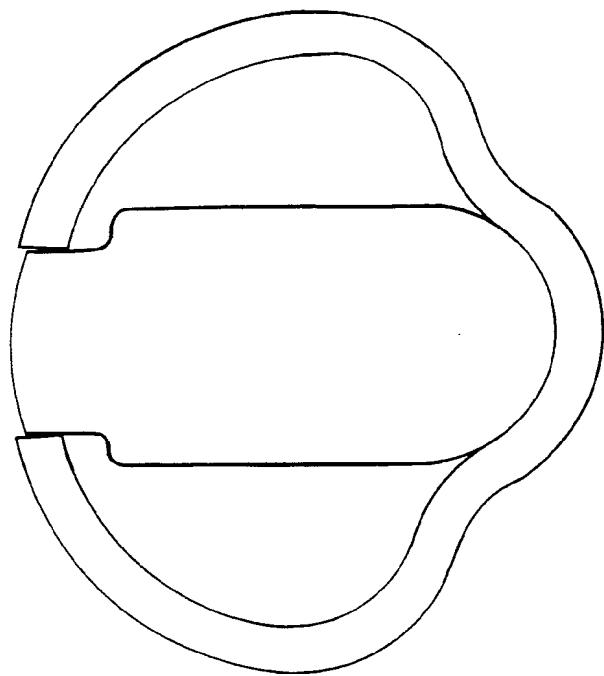


FIG. 4d

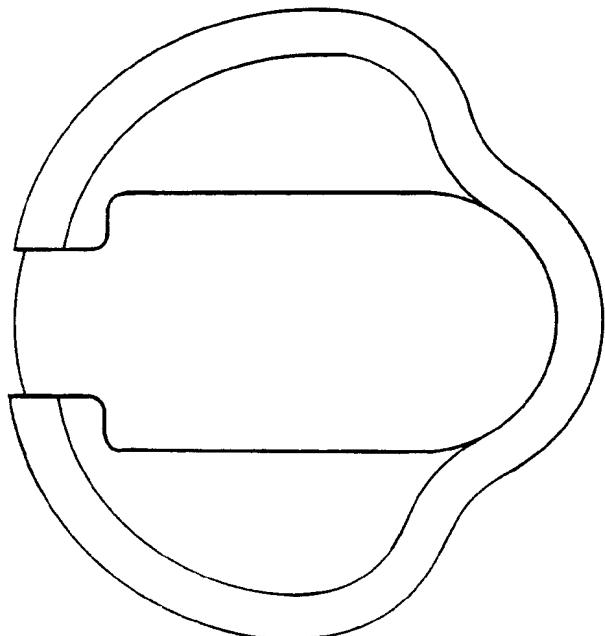


FIG. 4c

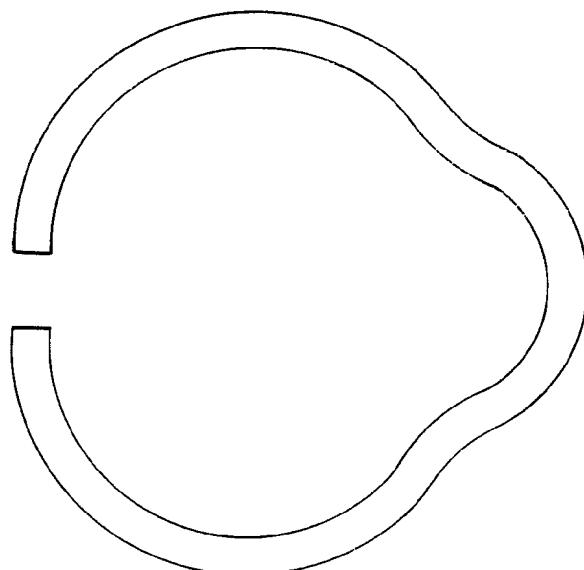


FIGURE 4f

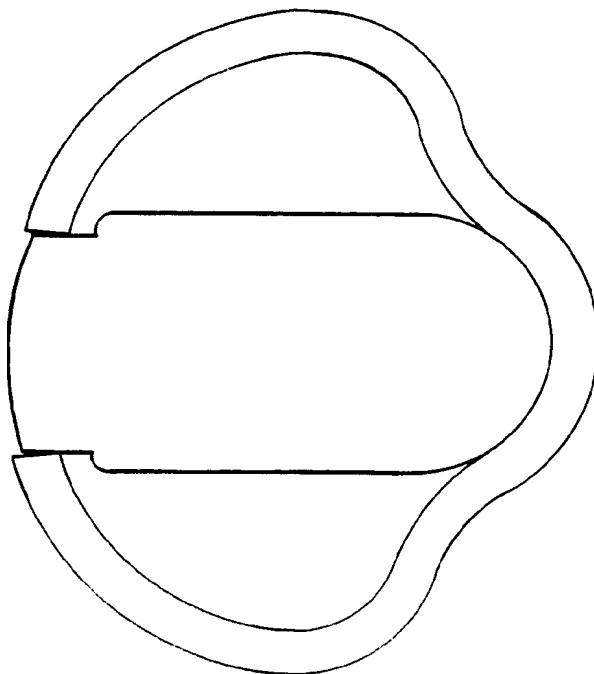


FIGURE 4e

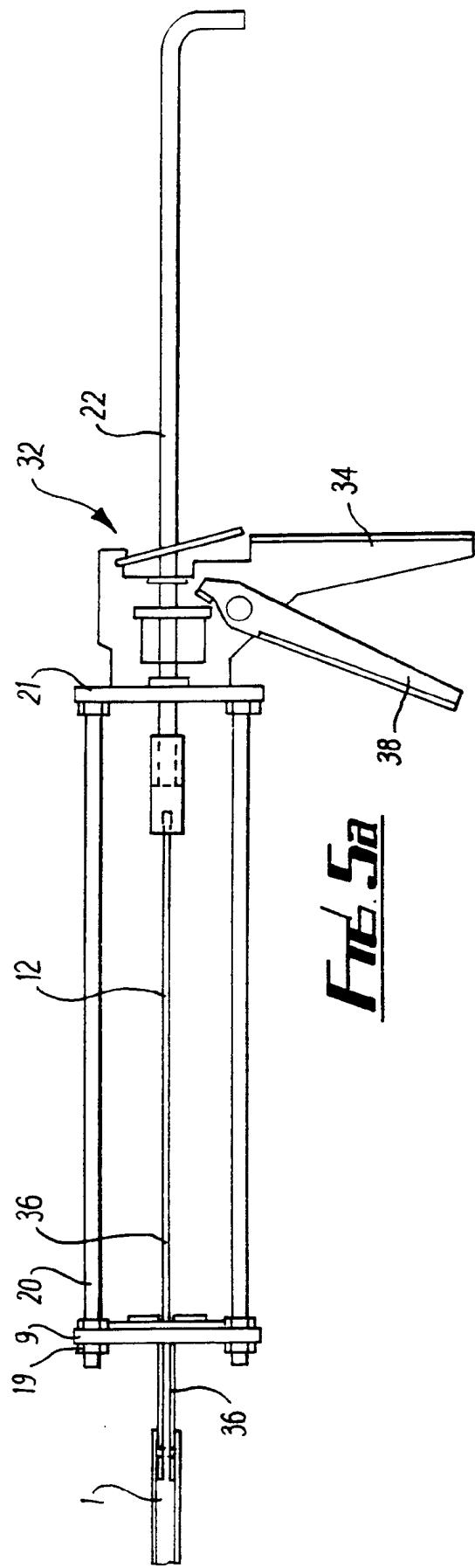


FIG. 5a

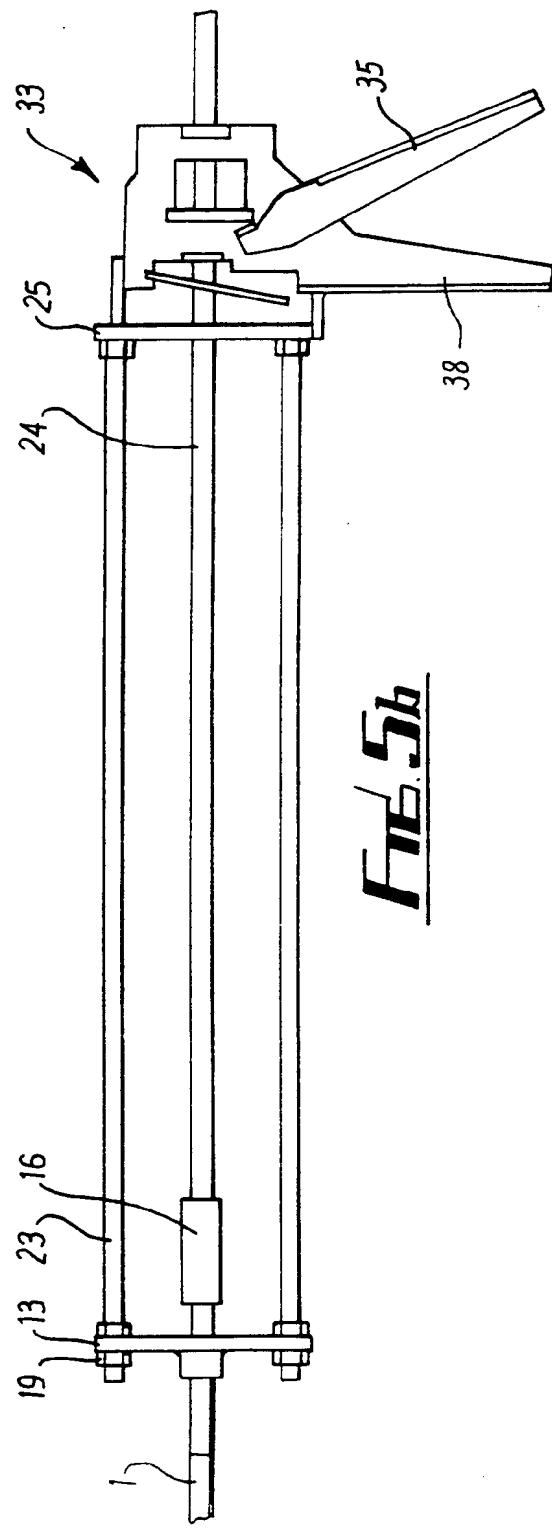
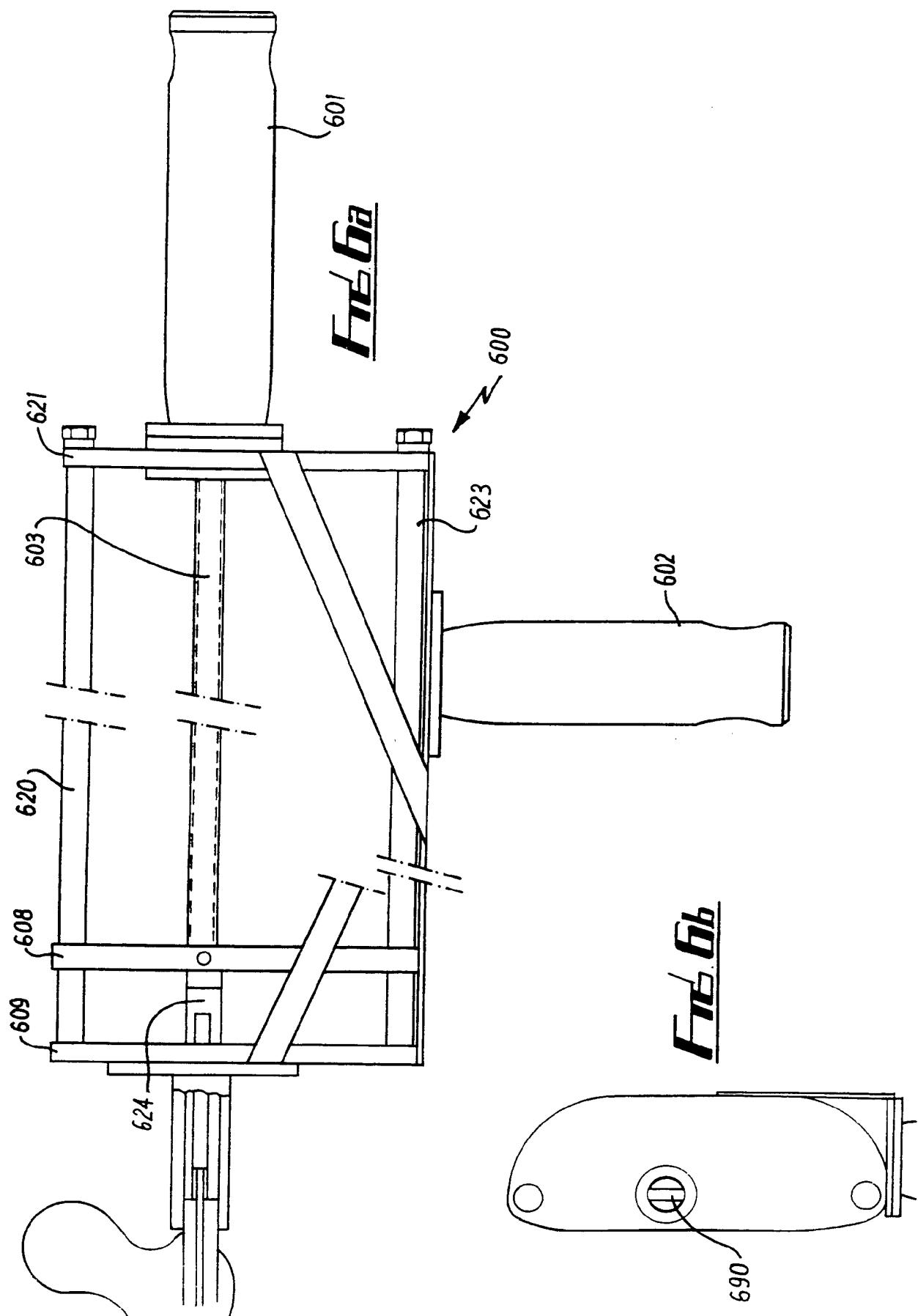
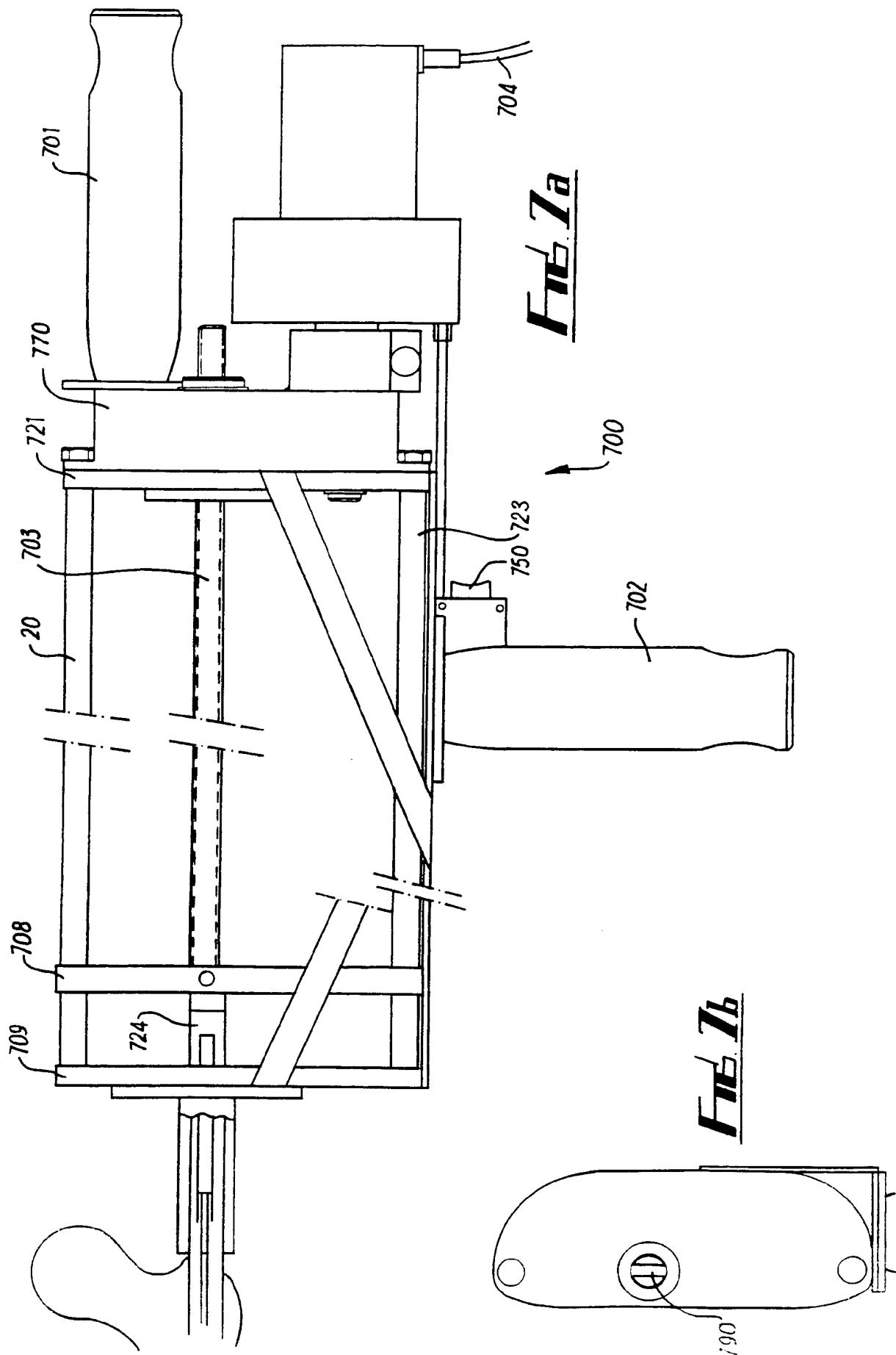
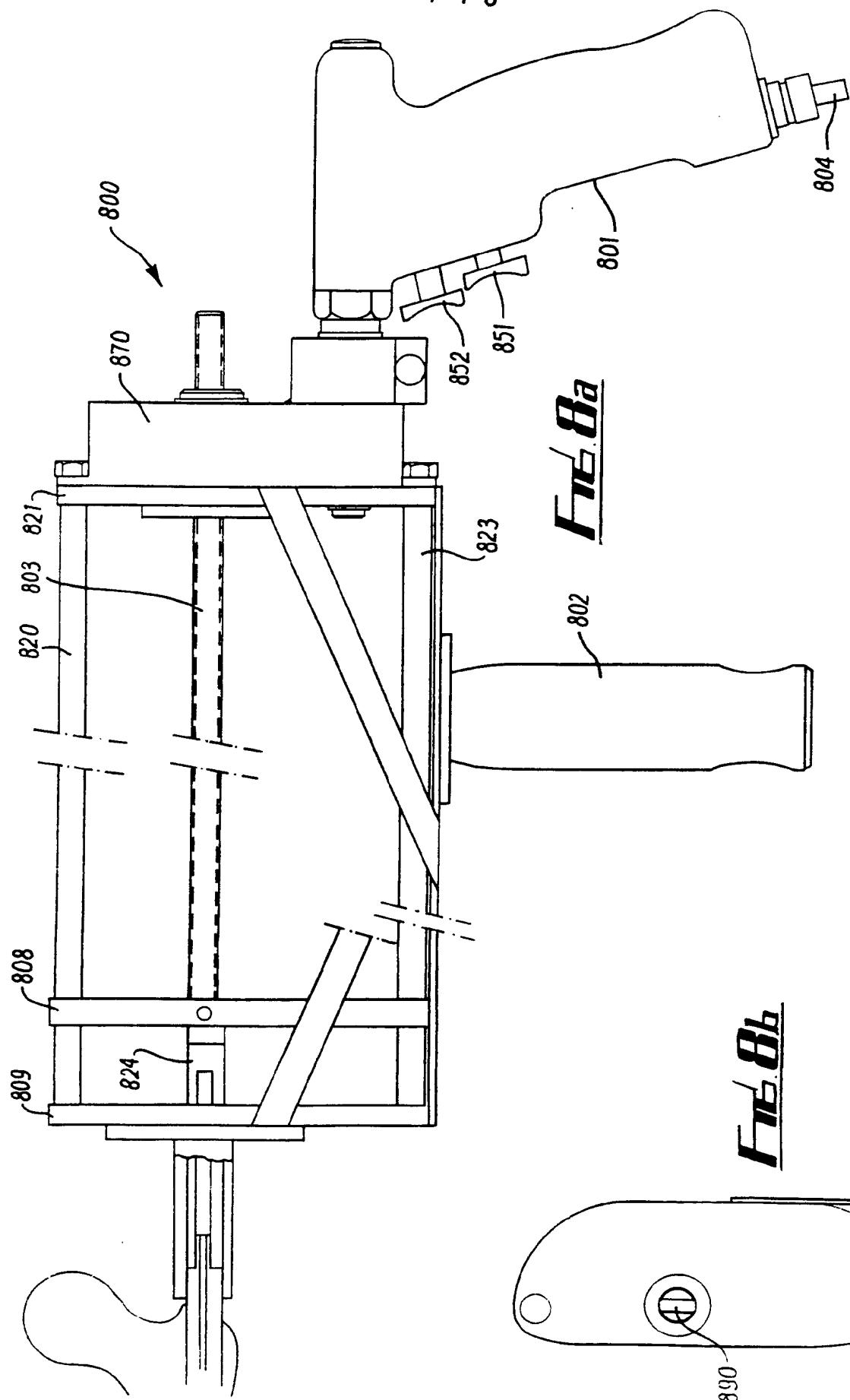


FIG. 5b







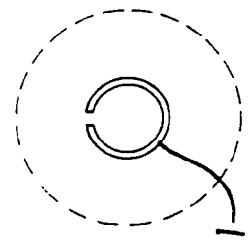


FIG. 9b

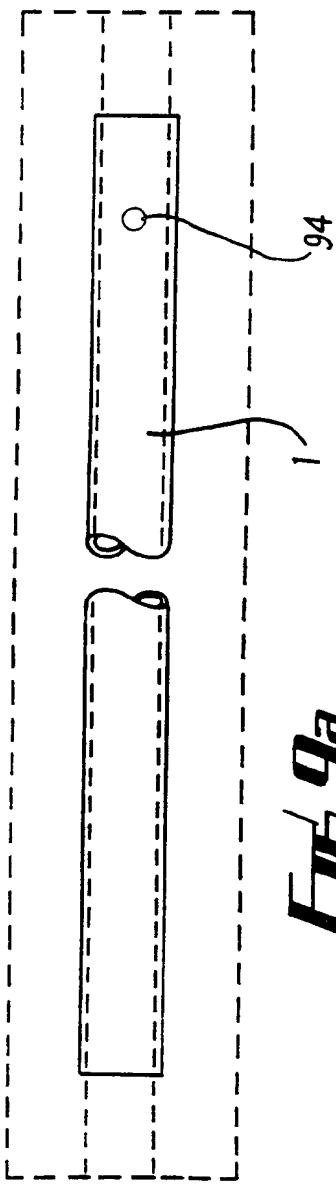


FIG. 9a

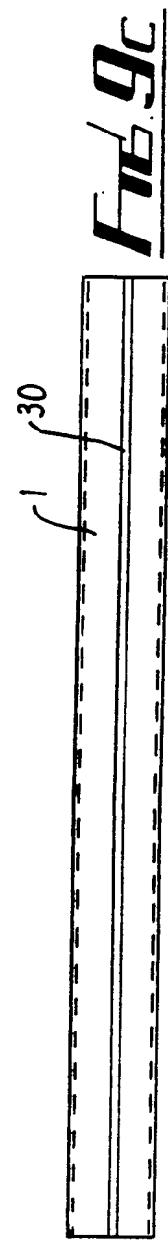


FIG. 9c

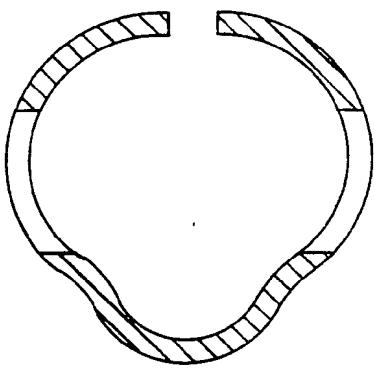


FIG. 10b

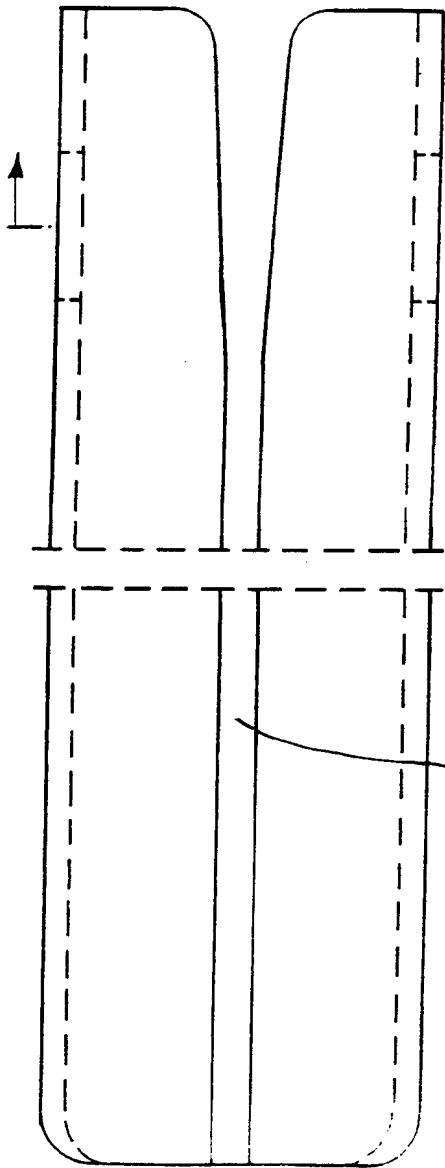


FIG. 10a



Fig. IIa



Fig. IIc

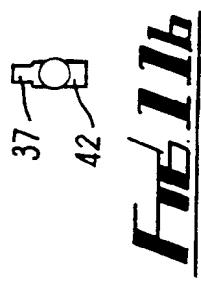


Fig. IIb

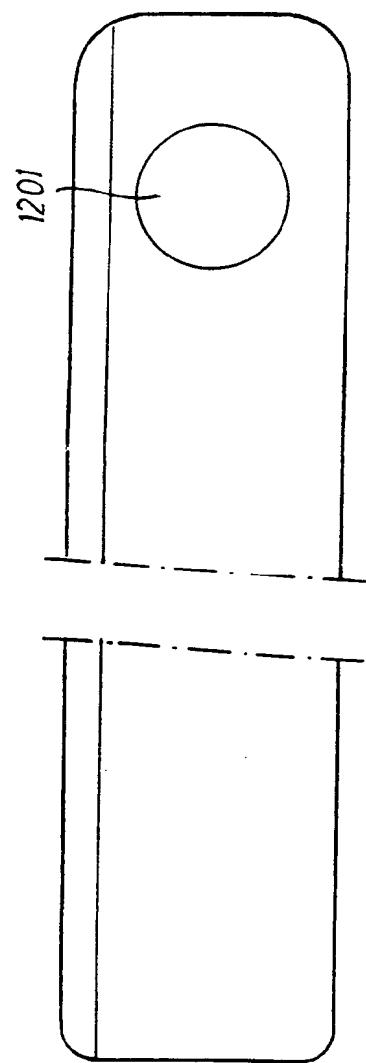
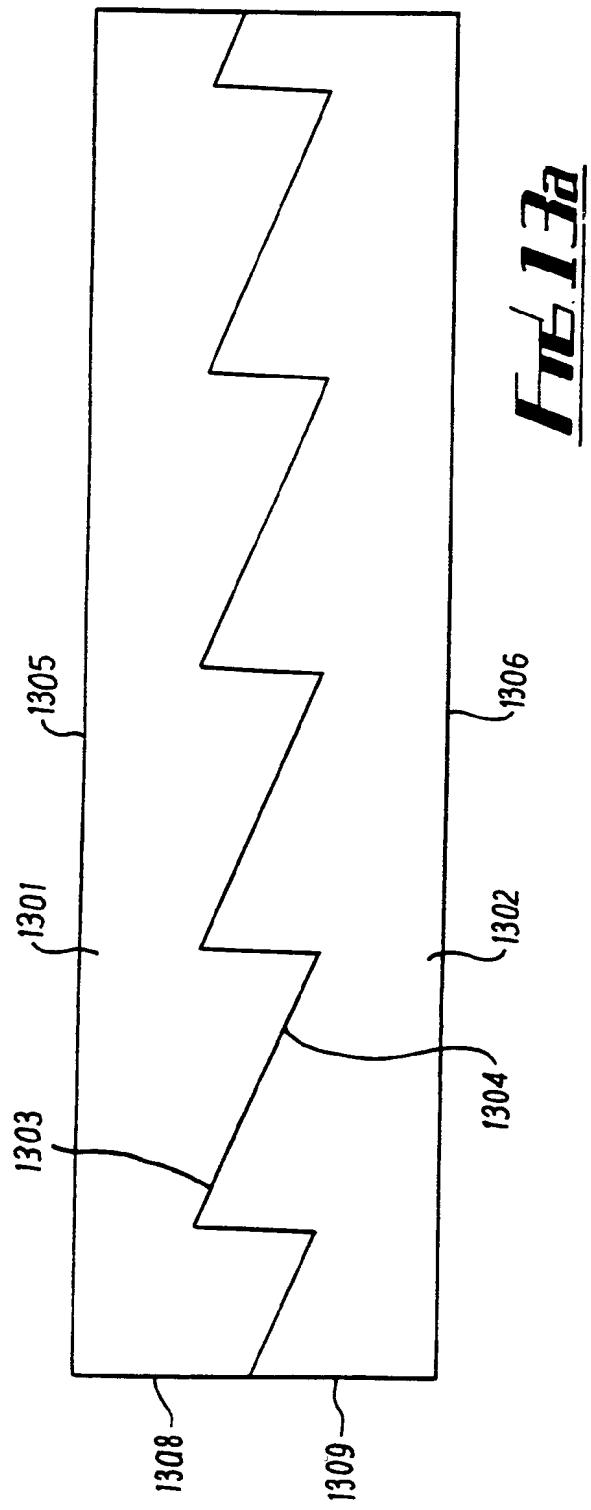
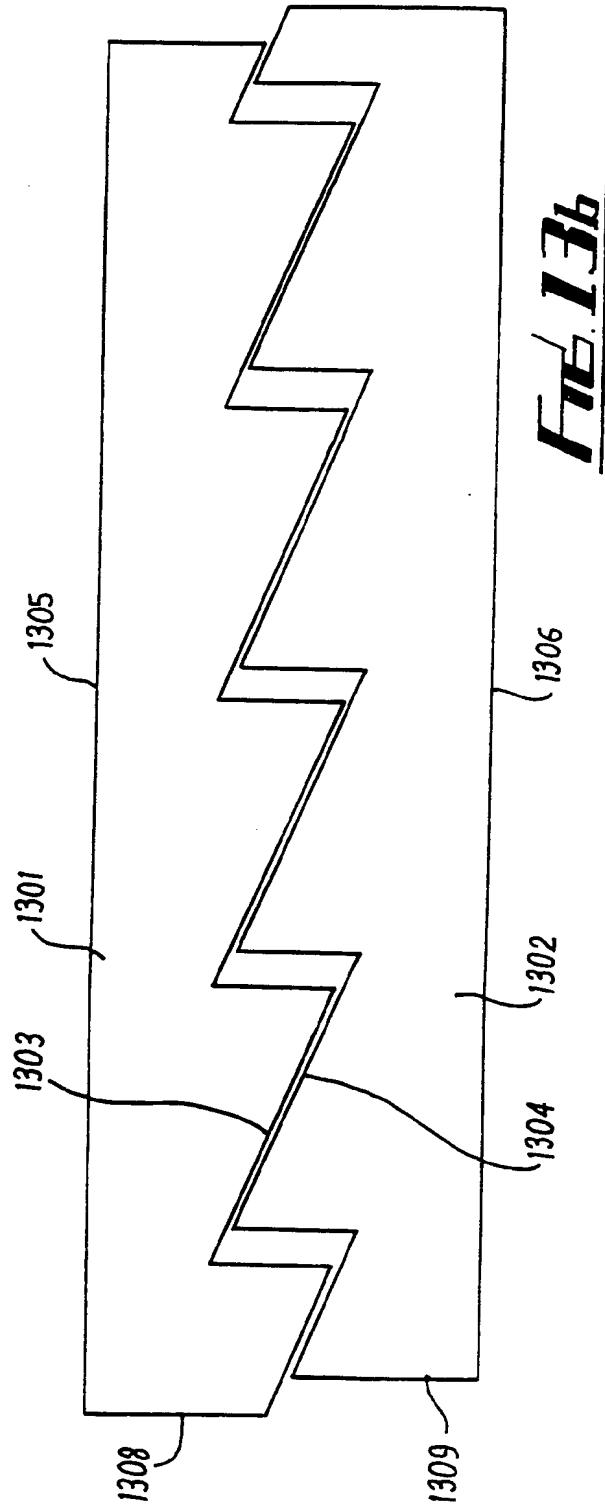


Fig. I2a





*FIG. 13a*



*FIG. 13b*

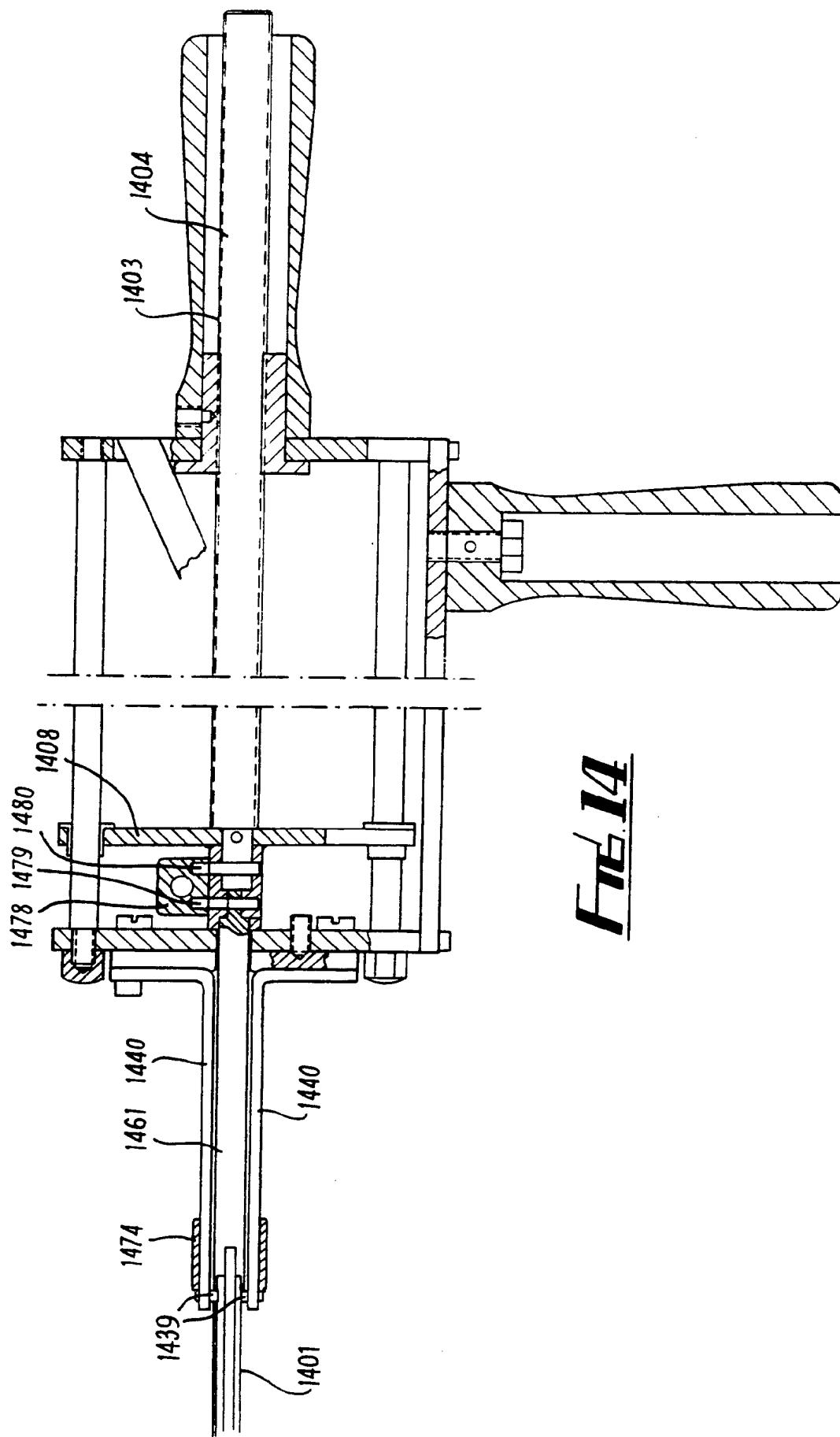




Fig 15a

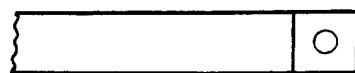


Fig 15b

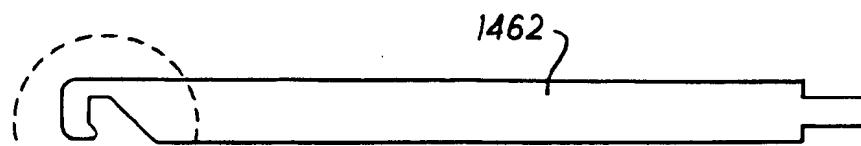


Fig 16a

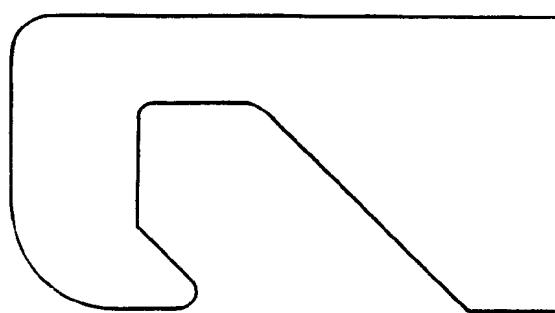


Fig 16b

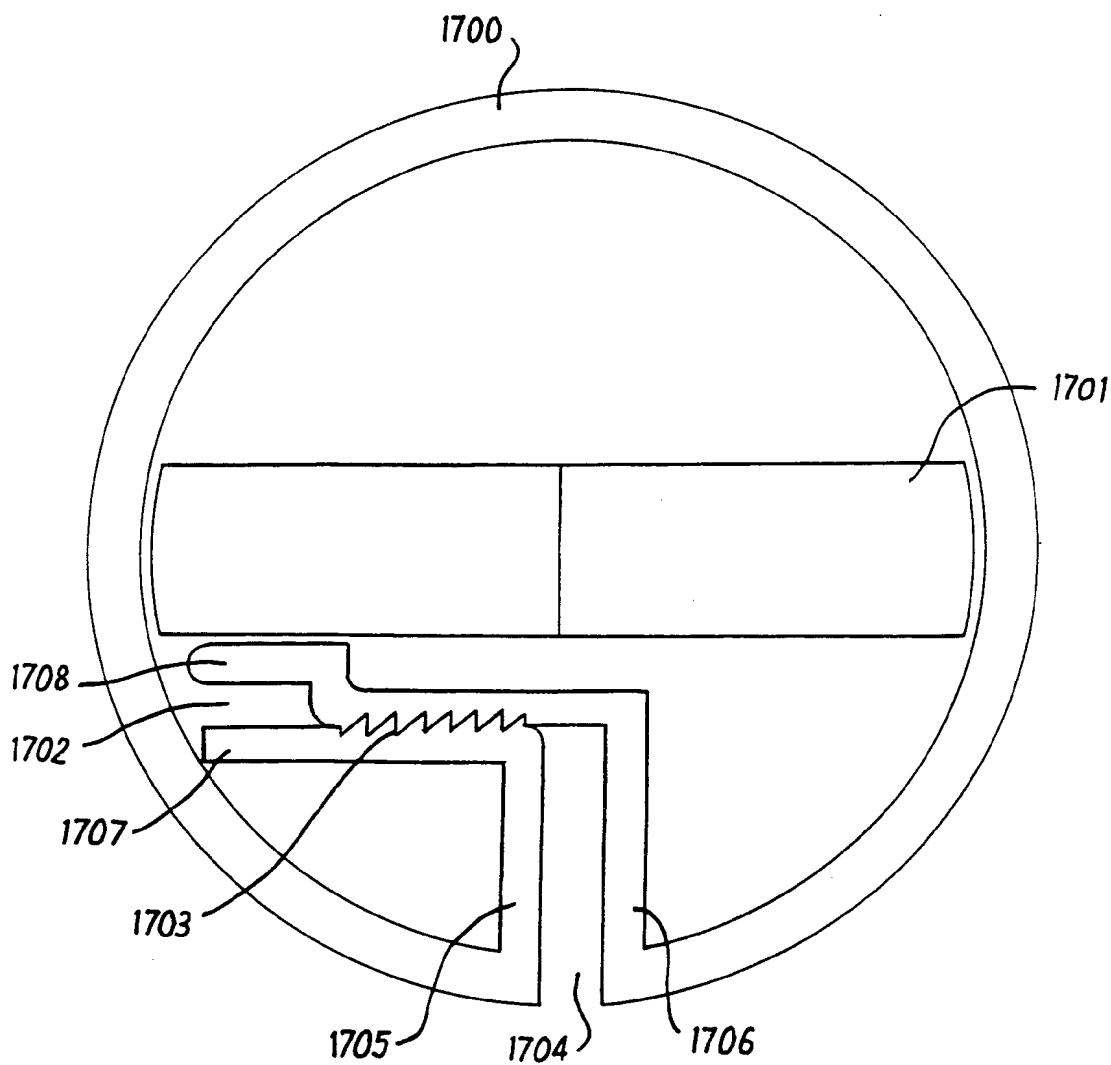


Fig. 17

## INTERNATIONAL SEARCH REPORT

Int. Application No

PCT/GB 93/02390

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 5 A61B17/58

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 A61B A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE,C,745 873 (POHL) 10 August 1953 see the whole document ---	1-9, 11-13, 15
A	US,A,5 116 335 (HANNON) 26 May 1992 see claim 1; figures ---	10
A	DE,U,84 00 640 (MECRON) 20 June 1985 see figures 3,4 ---	14
A	US,A,4 854 312 (RAFTOPOLUS) 8 August 1989 ---	
A	WO,A,88 01492 (OFFICE MEDICO CHIRURGICAL INTERNATIONAL) 10 March 1988 ---	
A	US,A,4 531 517 (FORTE) 30 July 1985 -----	

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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1

Date of the actual completion of the international search

10 March 1994

Date of mailing of the international search report

25.03.94

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Authorized officer

Steenbakker, J

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

Inte onal Application No

PCT/GB 93/02390

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
DE-C-745873		NONE		
US-A-5116335	26-05-92	NONE		
DE-U-8400640	20-06-85	NONE		
US-A-4854312	08-08-89	NONE		
WO-A-8801492	10-03-88	FR-A- 2606997 EP-A- 0278963 US-A- 4911722		27-05-88 24-08-88 27-03-90
US-A-4531517	30-07-85	NONE		